Ferrite Materials and Their Use in Anechoic Chambers

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INTRODUCTION

The word "anechoic" has Greek origins and roughly translates to mean "without echo." The use of anechoic chambers in both military and commercial testing for the control of electromagnetic energy reflection is a relatively recent development. Early applications of absorber material began in the 1960s. Originally pioneered by B. F. Goodrich, with their use of convoluted polystyrene foam sprayed with carbon, other companies improved on the technology with the use of rubberized horse hair impregnated with carbon and shaped to form a highly profiled surface. During the past few decades the predominant product to evolve for all broadband absorber applications was the carbon-loaded urethane cone. These products are available from a number of manufacturers and come in a variety of configurations.

With the introduction of more stringent testing requirements and particularly with the greater emphasis on the spectrum below 1 GHz, ferrite products have now evolved into the "state-of-the-art" in absorber technology. The use of ferrites in anechoic chambers is now well-proven and widespread, with the latest offering coming in the form of wideband ferrite grid products. The following discussion will provide an overview of currently available absorber products, and their relative advantages in providing solutions for chamber design to meet the new test standards.

Ferrite materials have found widespread acceptance as technical solutions for anechoic chamber construction which meets the new international standards for EMC testing.

THE EVOLVING STANDARDS ARENA

Any comprehensive discussion of the myriad standards for the testing of RF emissions and susceptibility is well beyond the scope of this article. Clearly, however, the bulk of the new chamber construction and retrofit activity in the marketplace is focused around areas concerned with three specifications: ANSI C63.4 (CISPR A), IEC801-3 and the new issues of MIL-STD-461D and 462D. Common to all of the specifications are requirements on the testing environment within a chamber. The chamber design, type and size will be determined by the characteristics of the absorber used. The available absorber products provide both technical and commercial tradeoffs that must be considered in building any new facility.

ABSORBER PRODUCTS FOR EMC TESTING

Pyramidal urethane is the traditional product, a polyurethane foam product impregnated by a carbon-carrying latex. Typically cut into 2-foot by 2-foot panels, the cone heights range from a few inches to 10 feet. Performance varies according to the degree of carbon loading and the shape and size of the cones. The longer cones are used for the low frequency (30 MHz) EMC test chambers. The advantages of pyramidal urethane are that it is effective over a broad frequency range and is available at a relatively low cost. Flammability, space inefficiency and performance degradation over time are among its disadvantages.

Ferrite tile is typically flat tile 4 inches square by about 1/4 inch thick. Thickness affects performance, as does composition of the ferrite material. Bandwidth performance is about 400 MHz and materials are generally fabricated to provide 16 to 20 dB attenuation at 30 MHz. Tiles are low profile — less than one inch thick — with a durable surface, and performance does not degrade with time. They are nonflammable. Currently available tiles are moderately expensive and limited in bandwidth.

Ferrite grids are 4-inch square by one-inch thick grids, which provide effective attenuation for emissions and susceptibility testing from 30 to 1000 MHz. Grid or lattice structure provides power handling characteristics and simplifies the installation problems of plain tile. They are low profile, have durable surfaces and good performance life. They are nonflammable, feature wideband performance, high power capabilities, and ease of installation. They are moderately expensive.

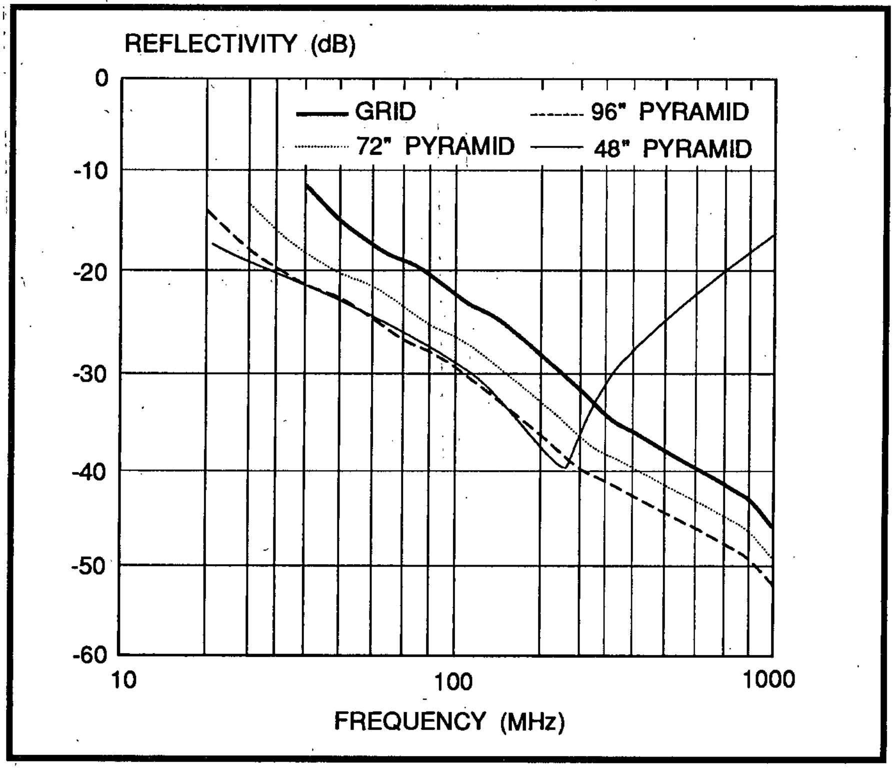

FIGURE 1. *Grid Absorber vs. Pyramidal.*

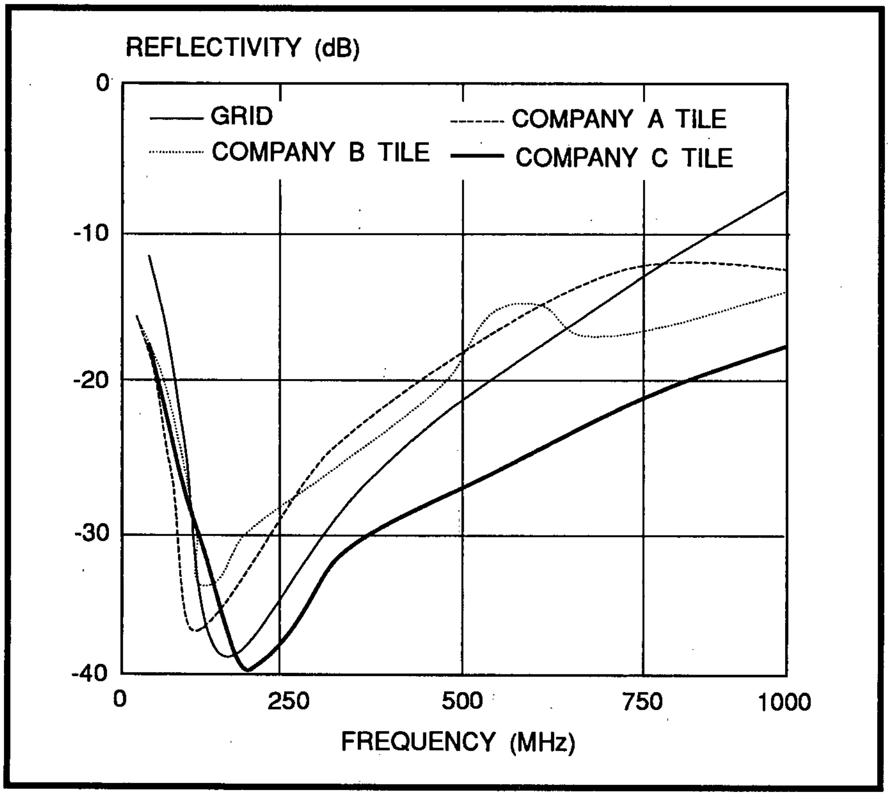

FIGURE 2. *Grid Absorber vs. Ferrite Tile.*

Urethane/Ferrite hybrid products use either the ferrite tile or grid absorbers, mounted on panels and then overlaid with a low carbon-loaded urethane or styrene cone absorber. The urethane and ferrite are carefully matched to extend the upper frequency performance of the ferrite. Tile products require 18 inches to 4 feet of urethane and the grid typically requires 5 to 18 inches. The hybrid composition extends the effective range of ferrite absorbers.

Figures 1 through 3 show typical performance of the many absorber products available on the market today. The characteristics of all products can be varied by their manufacturers to meet individual applications. Reflectivity data should be requested from each supplier when considering any new application. Performance data on existing installations should be requested by purchasers for their specific chamber type. Complete details of the chamber size, absorber location and test methods should be provided. All data should be swept over the frequency range and should not be limited to a few discrete points.

Figure 1 shows a comparison of urethane cones versus ferrite. Figure 2 compares ferrite tile to grid. Because of its broader bandwidth, the grid is able to meet the requirements of ANSI C63.4 and IEC801-3 compliant chambers. Figure 3 shows a ferrite tile and pyramidal cone hybrid product and how the upper end of the tile is extended.

ABSORBER PERFORMANCE BY APPLICATION

All of the absorbers discussed above can be used to fabricate anechoic chambers to meet the latest military and commercial testing requirements. Because of their divergent physical and performance characteristics, careful consideration must be given when selecting materials for new construction.

COMMERCIAL TESTING

Testing requirements for commercial products are governed by a

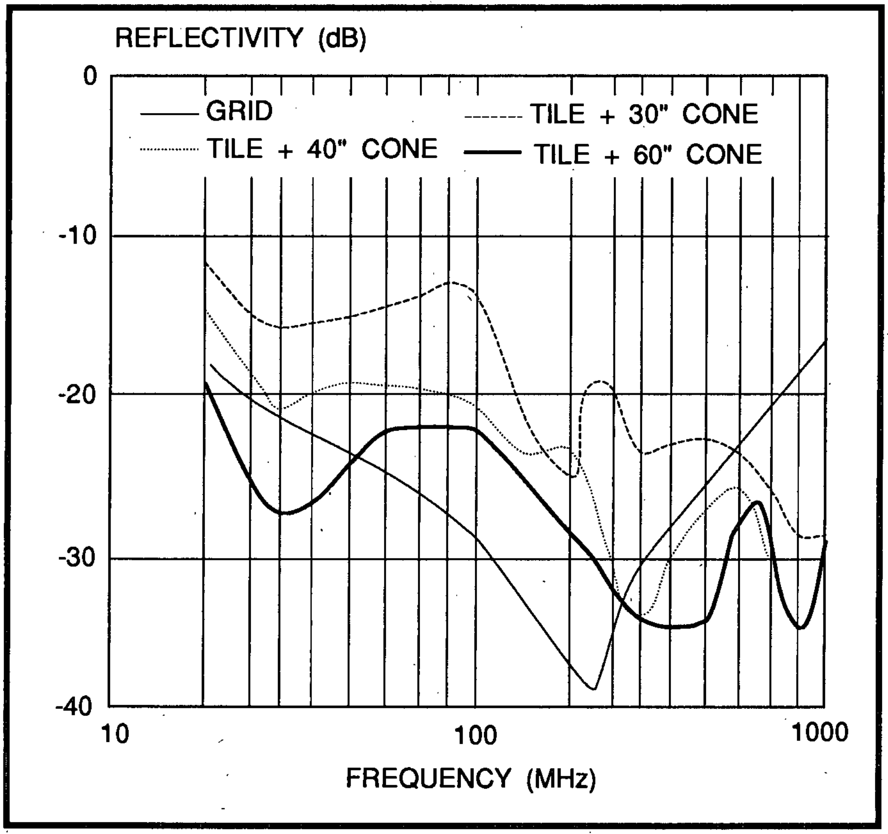

FIGURE 3. *Grid Absorber vs. Ferrite Hybrid.*

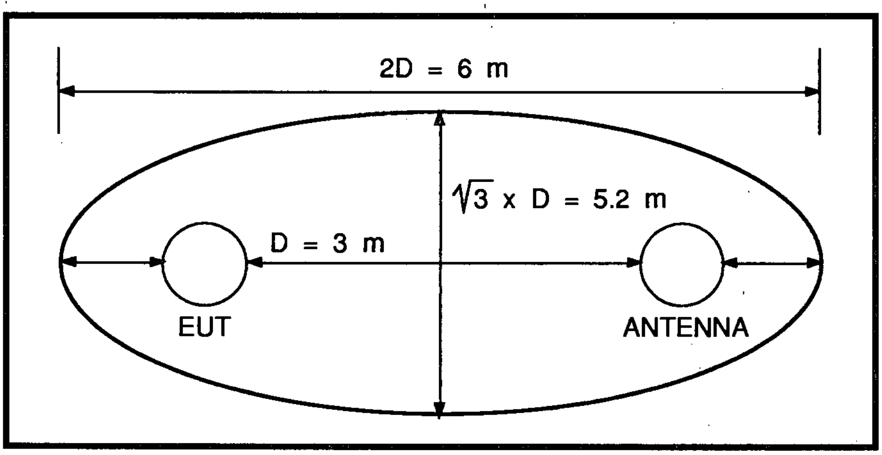

FIGURE 4. *Minimum Working Area.*

number of standards groups and regulatory organizations (FCC, USA; VCCI, Japan; CISPR, Europe). In recent years there has been dramatic movement to standardize testing limits and procedures, and to include requirements for anechoic chambers. ANSI C63.4 1991 (CISPR A Sec 109) and IEC801-3 are the main documents which set forth these test conditions.

When emissions testing is conducted in an anechoic chamber, it is normally done in either a 3- or 10-meter chamber. Figure 4 shows the space requirements for the floor area of a 3-meter chamber which is based on the old version of FCC OET-55. These emission chambers are semi-anechoic and utilize a reflective ground plane with absorbers on walls and ceiling. In order to meet the site attenuation requirements of ANSI C63.4, urethane products of up to 8 feet in thickness are required for these chambers. Ferrite tiles, as they have limited bandwidth performance, require a urethane or styrene hybrid which will vary from 18 inches to 4 feet depending on the supplier. These ferrite hybrids provide significant advantages over urethane-only chambers as they lessen size and cost. However, they still contain flammable materials, are easily damaged, and the hybrid materials deteriorate over time.

The ferrite grid absorber now provides the best solution for this type of construction. As no cone or wedge products are required, the total absorber thickness is less than one inch, allowing the final chamber to be significantly smaller than competitive offerings. The grid surface is very durable and nonflammable. The grid will also not exhibit any performance change over time, and since it screw-mounts to the RF shield room walls, refurbishment of the chamber can easily be accomplished.

Susceptibility testing per the requirements of IEC801-3 can be performed in either 3- or 10-meter chambers as described above with the use of an anechoic floor panel. The hybrid products and the ferrite grid are best suited for this use. So that the chamber operators need minimum changeover time to convert the room from emissions to susceptibility testing, the absorbers are arranged on panels which can be easily moved. As the grid is thin and durable, it provides the most practical solution. A floor panel of 10 feet by 11 feet placed between the transmit antenna and the equipment under test (EUT) in any properly constructed 3- or 10-meter chamber generally will

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performance was satisfactory. Installation conditions will be improved in the future to further enhance the performance of the EMP simulator. More details about the improvements made and the performance of the simulator thereafter appear in the proceedings of the 10th International Zurich Symposium on EMC.

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provide the 1.5 m by 1.5 m uniform field required by IEC801-3.

Ferrite absorbers also represent a practical solution for compact susceptibility chambers. Ferrite tiles used in conjunction with 18-inch urethane allow for chambers that are 10 feet by 23 feet by 13 feet high in which susceptibility testing can be performed. As these compact work areas are quite confined, durability of the grid is an important feature. All of these compact chambers are fully anechoic and have absorber material on all surfaces.

MILITARY TESTING

MIL-STD-461 and 462 have been revised and deal more specifically with the issue of anechoic materials. Quite simply, an absorber that provides 6 dB of attenuation from 50 to 250 MHz and 10 dB above 250 MHz will be required. The recommendation is to place the absorber on the EUT end wall, to each side of the EUT, above the EUT, and behind the test antenna. Urethane cones can be used to meet this requirement, but again have the disadvantage of their inefficient use of chamber space. Ferrite tile hybrids lessen this problem to some extent, but still require up to 18 inches of absorber height. This is particularly cumbersome in bench-tested equipment. Once again, the ferrite grid absorbers offer the best alternative. The grid's upper frequency must be extended and with a 5-inch urethane overlay, can meet the 10-dB requirement to 20 GHz. In chambers where high-power testing is required (200 V/m and up), the urethane can, with a temporary mounting system, be removed, leaving only the non-flammable grid.

CONCLUSION

Recently ferrite absorber products have found widespread acceptance in anechoic chamber construction. They offer increased space efficiency, long performance life, and are not flammable. The newest generation of ferrite grid absorbers now provides for chamber construction without the use of any urethane products. As international and domestic regulations demand more complete testing of commercial products, there will be an increased need for compliant chambers. Ferrites will provide additional solutions for new chamber construction.

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